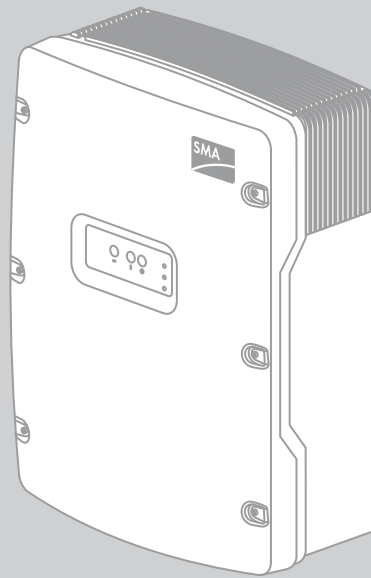


# Battery Management

Gentle charging control based on current state of the battery

## SUNNY ISLAND



## Contents

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Exact determination of the state of charge is a basic requirement for correct operation of the battery and maximum battery life. Battery management of the Sunny Island supports lead acid batteries of the following types:

- FLA
- VRLA

The following description applies exclusively to the two battery types FLA and VRLA.

Battery management of the battery inverter, Sunny Island, is based on precise determination of the state of charge. By combining the three most common methods of state of charge determination, the Sunny Island achieves a measurement accuracy of more than 95%. This reliably prevents overcharging and deep discharging of the batteries.

A further feature of battery management is the exceptionally gentle charging control. This automatically ensures an optimal charging strategy appropriate to the battery type and the situation. This means that overcharging can be reliably prevented and that the battery can regularly be fully charged. The available charge energy is used optimally at all times.

# 1 State of the Battery

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## 1.1 Usable Battery Capacity

The usable capacity of a new battery corresponds to the nominal capacity, specified by the manufacturer, for a ten-hour discharge (C10). As the battery ages, its usable capacity drops due to the following reasons:

- Calendrical ageing
  - If not used, the usable capacity of the battery drops.
- Cycling
  - The battery ages through use. The battery age is influenced by the depth of the discharge cycles.

Battery ageing is also influenced by various other factors, e.g. by insufficient charging, excessive charging voltages, deep discharging or temperature. With the correct choice of the battery parameters, battery management can influence these factors and conserve the battery.

### **Temperature Influence:**

The current usable battery capacity depends on the temperature of the battery. With temperatures of 20°C and below, the usable capacity of a battery drops significantly. Battery management corrects the usable battery capacity by – 1% per °C.

### **Current Usable Battery Capacity:**

Battery management shows the current usable battery capacity expressed as a percentage of the nominal capacity as state of health (SOH). After initial commissioning of the system, battery management requires a number of charging cycles before it can measure with reasonable accuracy the current usable battery capacity. For this reason, battery management initially uses the nominal capacity specified in the Quick Configuration Guide.

## 1.2 Current State of Charge

Battery management shows the current state of charge of the battery.

### **Estimated Error of the State of Charge:**

The estimated error of the state of charge provides information concerning the accuracy of the current calculation of the state of charge of the battery.

The deviation between the displayed state of charge and the actual value decreases with every charging procedure.

## 1.3 Battery Temperature

Battery management continuously monitors the battery temperature. The Sunny Island adjusts the specification of current usable battery capacity and charging voltage for the current battery temperature (see Section 2.3 "Automatic Temperature Compensation", page 6).

Battery management issues a warning message if one of the following events occurs:

- The battery temperature is within 5°C of the maximum permissible battery temperature.
- The battery temperature is less than -10°C.

If the maximum permissible battery temperature is exceeded, Sunny Island switches itself off. As soon as the battery has cooled down to a predefined temperature, Sunny Island starts again.

# 2 Charge Control

## 2.1 Charging Phases

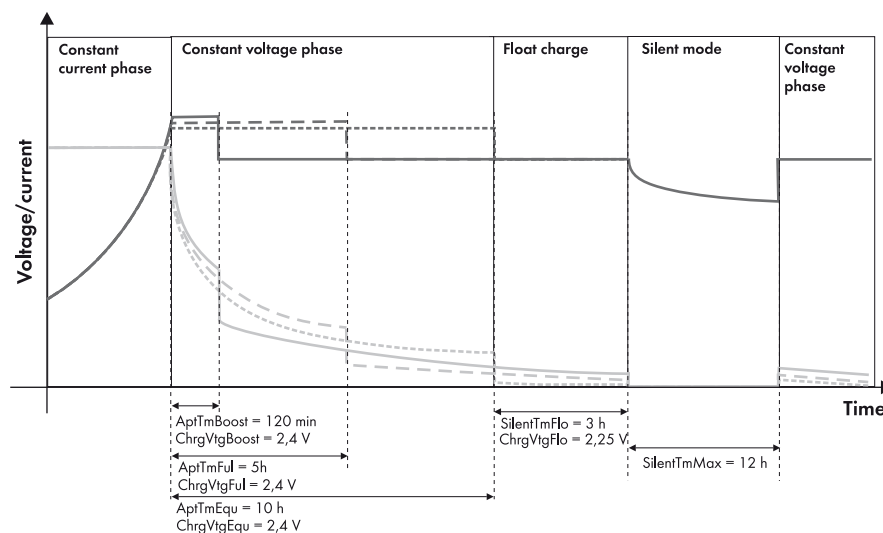


Figure 1: Sunny Island charging phases with sample values for an AGM battery. The parameters specified can be adjusted for the battery used according to manufacturer specifications.

Sunny Island controls charging of the battery in the following three phases:

- Constant current phase (I phase/bulk phase)
- Constant voltage phase (absorption phase/U<sub>o</sub> phase)
- Float charge/U phase

There is also the idle phase in the case of electricity grid operation with activated silent mode.

### Constant Current Phase

During the constant current phase, the primary task of battery management is to limit the current to the maximum permissible battery current. You can adjust the maximum charging current by changing the parameter **BatChrgCurMax** to the value specified by the battery manufacturer.

The battery charging current that is available is also limited by two further parameters:

- Nominal currents of the external energy sources (parameters **GdCurNom** and **GnCurNom**)
- Maximum AC charging current of the Sunny Island (parameter **InvChrgCurMax**)

The value that is reached first limits the charging current of the battery. Whereas the charging current is maintained within the defined limiting values, the battery voltage increases as the battery is charged. The constant current phase ends when the cell voltage of the battery reaches the setpoint specified for the relevant battery type.

### Constant Voltage Phase

In the constant voltage phase, the battery voltage is controlled at a constant value. As a result, the battery current decreases continuously.

For the constant voltage phase, battery management selects one of the following three charging processes (see Section 2.2 "Charging Process During the Constant Voltage Phase", page 5):

- Boost charge
- Full charge
- Equalisation charge

For each of these three charging processes, you can adjust the level of voltage and the charging time in the Sunny Island to the specifications of the battery manufacturer. When the required charging time has been reached, the constant voltage phase ends and Sunny Island switches to float charge.

### Float Charge

The purpose of float charge is to maintain the battery in a fully charged state without overcharging it. At the beginning of float charge, battery management reduces the charging voltage in steps until the target value specified for float charge has been reached. Battery management then maintains this charging voltage until the end of float charge. Float charge ends when one of the following conditions is met:

- The total of all discharges of the battery has reached 30% of the nominal capacity.
- The current state of charge is less than 70% of the available charging capacity.

Battery management switches from float charge to the constant current phase. If the stand-alone grid is connected to the electricity grid, battery management can also switch from float charge to silent mode.

### Silent Mode

In silent mode, Sunny Island switches to standby and thus saves energy.

If the set time for the float charge (parameter **SilentTmFlo**) has expired in systems with electricity grid operation, battery management switches to silent mode and any connected loads are supplied exclusively from the electricity grid. The Sunny Island leaves silent mode at definable intervals (parameter **SilentTmMax**) or whenever the battery voltage per cell drops by 0.14 V. This way, the battery always remains fully charged.

## 2.2 Charging Process During the Constant Voltage Phase

When moving to the constant voltage phase, battery management selects one of the following charging processes:

- Boost charge
- Full charge
- Equalisation charge

### Boost Charge

For boost charge, a high charging voltage is applied to the battery. The battery is to be charged to between 85% and 90% of its current usable capacity in a very short time.

You can adjust the charging voltage (parameter **ChrgVtgBoost**) and the time period (parameter **AptTmBoost**) in accordance with the recommendations for the battery used.

### Full Charge

The aim of full charge is to charge the battery to a state of charge of at least 95%. This should compensate for effects caused by any insufficient charging and should also increase the service life of the battery.

The Sunny Island carries out a full charge of the battery whenever one of the following conditions is met:

- The defined cycle time for the full charge has expired (parameter **CycTmFul**).
- The total of all discharges since the last full charge corresponds to eight times the nominal capacity of the battery.

You can adjust the charging voltage (parameter **ChrgVtgFul**) and the time period (parameter **AptTmFul**) in accordance with the recommendations for the battery used.

### Equalisation Charge

With the equalisation charge, the Sunny Island cancels out differences in the state of charge of individual battery cells which have arisen due to the different behaviours of the battery cells. This way, the Sunny Island prevents the premature failure of individual battery cells and extends the service life of the battery.

The Sunny Island carries out an equalisation charge of the battery if the automatic equalisation function is activated and if one of the following conditions is met:

- The defined cycle time for the equalisation charge has expired (parameter **CycTmEqu**).
- The total of all discharges since the last equalisation charge corresponds to 30 times the nominal capacity of the battery.

You can adjust the charging voltage (parameter **ChrgVtgEqu**) and the time period (parameter **AptTmEqu**) in accordance with the recommendations for the battery used.

To maintain or service the battery in systems that are only operated seasonally, you can start an equalisation charge manually (see Sunny Island operating manual).

## 2.3 Automatic Temperature Compensation

The charging capability of the battery is dependent on temperature. To prevent overcharging and insufficient charging of the battery, battery management is equipped with automatic temperature compensation.

With temperatures above 20°C, battery management decreases the charging voltage. With temperatures below 20°C, battery management increases the charging voltage.

# 3 Battery Protection Mode

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Battery protection mode protects the battery.

If the battery's state of charge falls below defined limiting values, battery protection mode is activated. In battery protection mode, Sunny Island switches to standby or switches itself off. Battery protection mode has three levels. For each level, you can set one state of charge limiting value. Levels 1 and 2 of battery protection mode have specific start and end times and are therefore dependent on the time of day.

### Level 1

If the state of charge drops below the limiting value for level 1 at any time between the start time and end time, the Sunny Island switches to standby. This way, you can specify times for which you prefer the stand-alone grid to be switched off if there is an energy deficit.

### Level 2

If the state of charge drops below the limiting value for level 2, the Sunny Island switches to standby. During the day, when PV inverters can supply energy, the Sunny Island attempts to charge the battery.

Using the start time and end time, you define the time period during which the Sunny Island starts every two hours in order to charge the battery. If no energy is available to charge the battery, the Sunny Island remains on standby.

### Level 3

If the state of charge drops below the limiting value for level 3, the Sunny Island switches itself off. This protects the battery against deep discharge and severe damage. To charge the battery again, the Sunny Island must be switched on and started manually.

At all three levels, the Sunny Island only switches to standby or switches itself off if no charging current flows within six minutes.

You can adjust the limiting values for battery protection mode to suit the system (see Changing Battery Protection Mode in the Sunny Island installation manual).